Testing Specific Construction Products for Ecotoxicity

Michael Burkhardt[1], Mirko Rohr[1], Etiënne Vermeirssen[2], Ines Heisterkamp[3], Stefan Gartiser[3]

1 HSR University of Applied Sciences, Rapperswil, Switzerland
2 Swiss Centre for Applied Ecotoxicology, Dübendorf, Switzerland
3 Hydrotox GmbH, Freiburg/Br, Germany

Vilnius, 17th October 2019

HSR
HOCHSCHULE FÜR TECHNIK
RAPPERSWIL SWITZERLAND

UNIVERSITY OF APPLIED SCIENCES

Hydrotox
LABOR FÜR ÖKOTOXIKOLOGIE UND GEWÄSSERSCHUTZ GMBH
FREIBURG

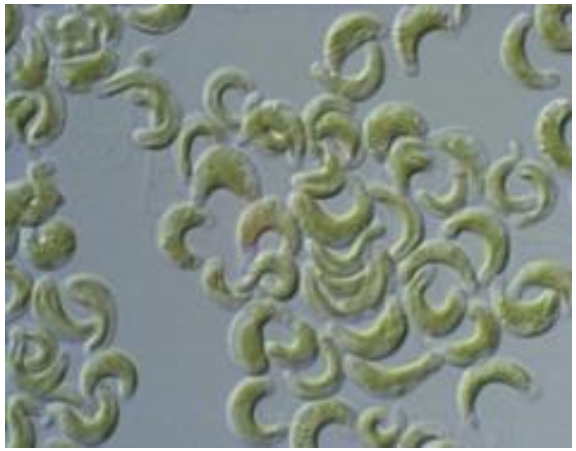
oekotoxzentrum
centre ecotox
Schweizerisches Zentrum für angewandte Ökotoxikologie
Centre Suisse d'écotoxicologie appliquée
Eawag-EPFL

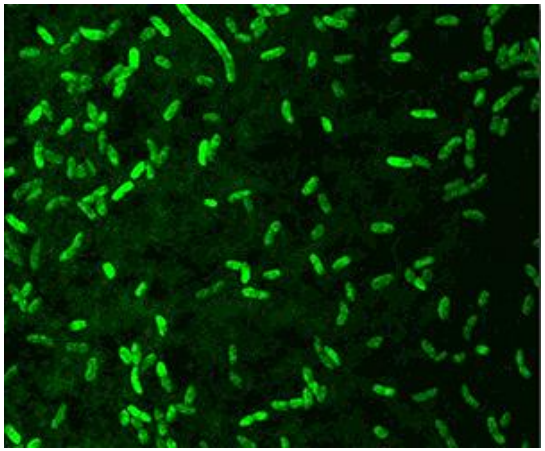
Motivation for Ecotoxicological Testing

- Huge variety of construction products
- Laboratory leaching tests CEN/TS 16637-2, -3, EN 16105
- Leached substances often unknown

Bioassays Toolbox

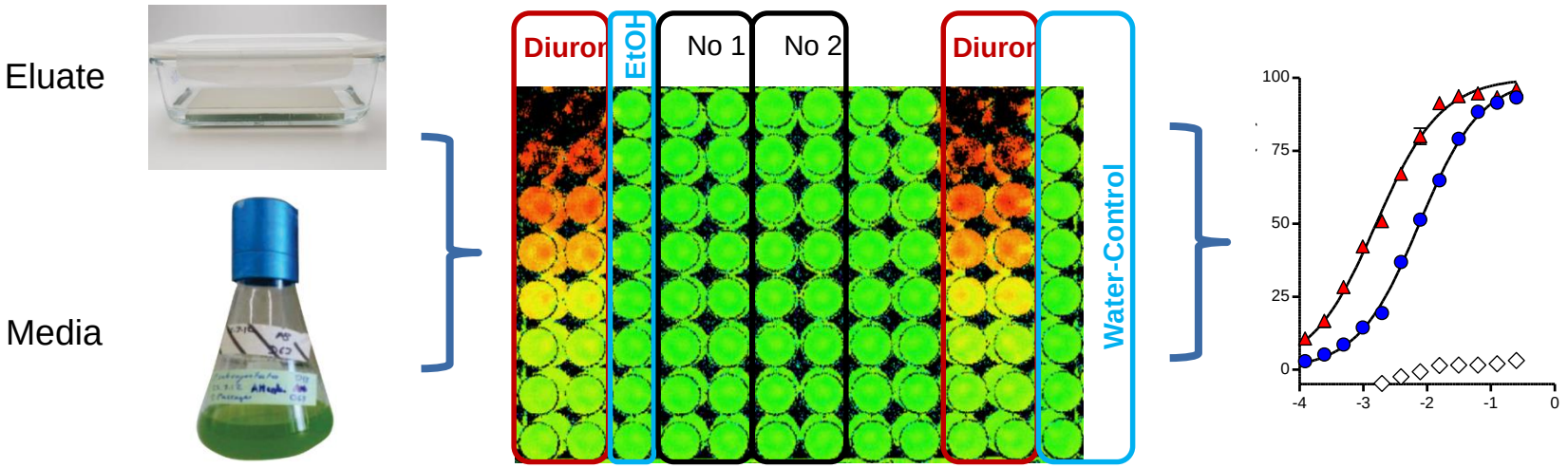
- Minimum battery focusing on acute ecotoxicity (CEN/TR 17105)
  - Algae: Photosynthesis inhibition (short term) or growth rate (ISO 8692)
  - Daphnia: Mobility after 24 h or 48 h (ISO 6341)
  - Luminescent bacteria: Bioluminescence (EN ISO 11348-2)
- Results are expressed as Lowest Ineffective Dilution (LID)





Bioassays: General Procedure

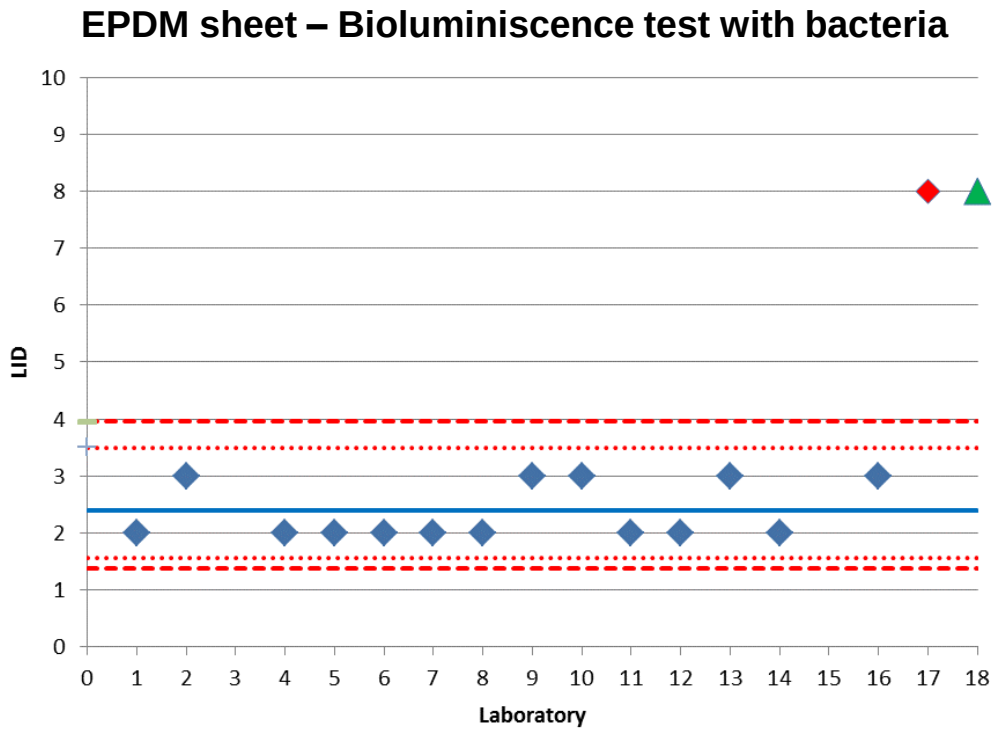
- Eluate diluted with media step-by-step to derive dose-response curve
  - e.g. LID 2, 4, 8, 12, 16, 32, 64
- Limit values (DIBt concept, CEN/TR 17105)
  - LID > 4 for algae and daphnia
  - LID > 8 for luminescent bacteria



Picture: Photosynthesis inhibition of algae

Bioassays: Reproducibility

- Round robin test demonstrates reproducibility of bioassays
  - 12 Laboratories across Europe taken part (blue: geometric mean)



Gartiser et al. (2017): Results from a round robin test for the ecotoxicological evaluation of construction products using two leaching tests and an aquatic test battery. Chemosphere, 175:138-146.

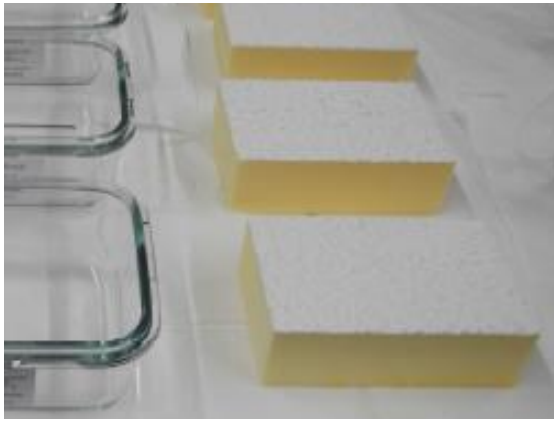
Three Examples of Ecotoxicological Evaluations

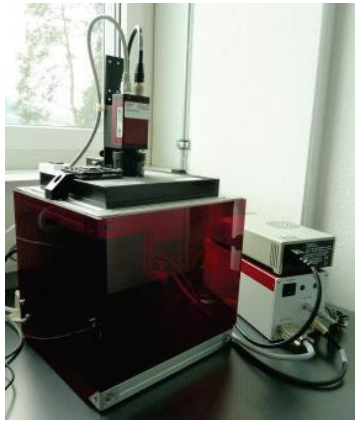
- Render with biocides used as film preservatives
  - Immersion test with 9 eluates (EN 16105)
- Corrosion protection coatings (epoxy resins, polyurethane)
  - Single samples with 7 days water contact
- Rooftop membranes – EPDM, PVC, FPO (flexible sheets)
  - DSLT with 8 eluates (CEN/TS 16637-2)

Funded by German EPA (UBA), Swiss EPA (FOEN), City of Zurich

Render

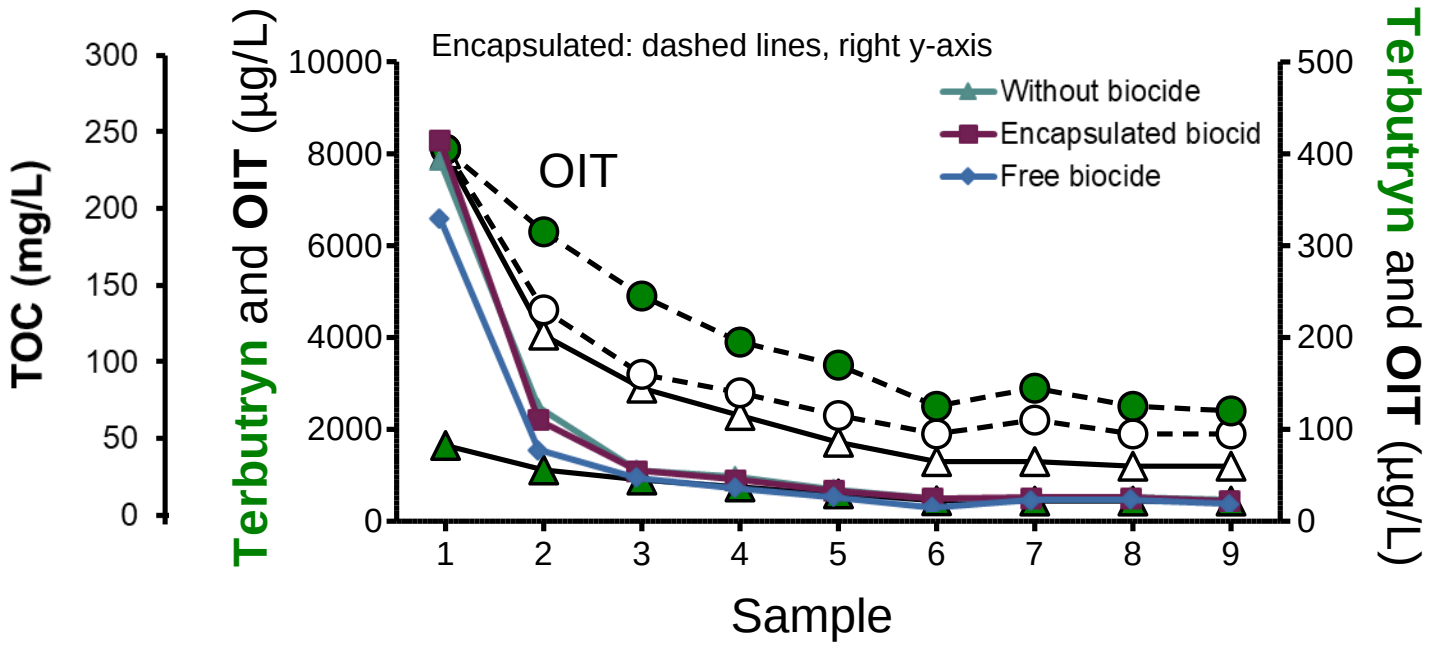
- Polymeric render containing free and encapsulated biocides
  - Initial amount 750 ppm Terbutryn, OIT, and DCOIT added
- Products applied on XPS substrate (100 cm^2)
- Chemical analysis of biocides, transformation product M1, TOC
- Three bioassays with 1^{st} and 9^{th} eluates





Render: Leaching

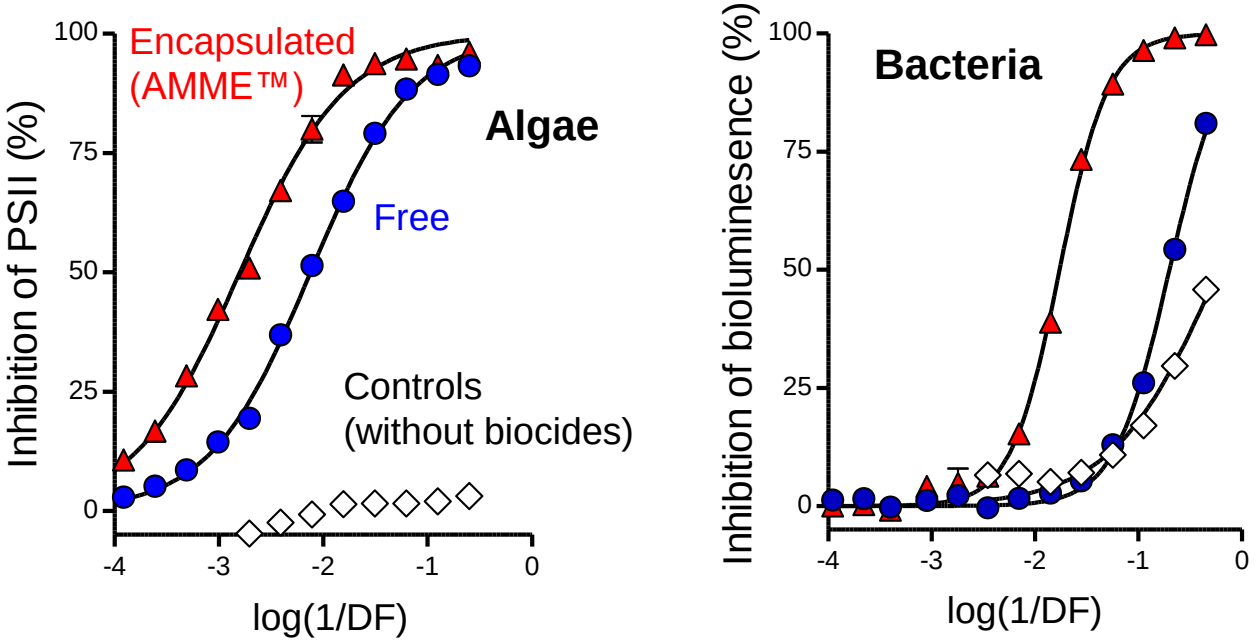
- Substance properties influence the leaching (OIT > Terbutryn)
- Leaching of biocides is reduced by encapsulation
- TOC provides no insight to specific substances
  - Control without biocides shows similar TOC pattern



Vermeirssen et al. (2018): Ecotoxicological Assessment of Immersion Samples from Facade Render Containing Free or Encapsulated Biocides. Environ. Tox. Chem., 37(8), 2246-2256

Render: Bioassays

- Encapsulated biocides less toxic (e.g. Algae EC_{50}: DF 630 vs. DF130)
- Control without biocides show no / small effect (but high TOC)
- Effects fits well with measured biocides concentrations
  - Concentrations and toxicity fell at 5-fold from 1st to 9th sample (not shown)



Vermeirssen et al. (2018): Ecotoxicological Assessment of Immersion Samples from Facade Render Containing Free or Encapsulated Biocides. Environ. Tox. Chem., 37(8), 2246-2256

Corrosion Protection Coatings

- 7 Epoxy and 1 PU resin prepared according to producer instructions
- Products applied onto glass plates (100 cm^2) and leached for 7 d
- Chemical analysis of Bisphenol A (BPA), F (BPF), BADGE, TOC
- Three bioassays with a single water sample

Corrosion Protection Coatings: Leaching

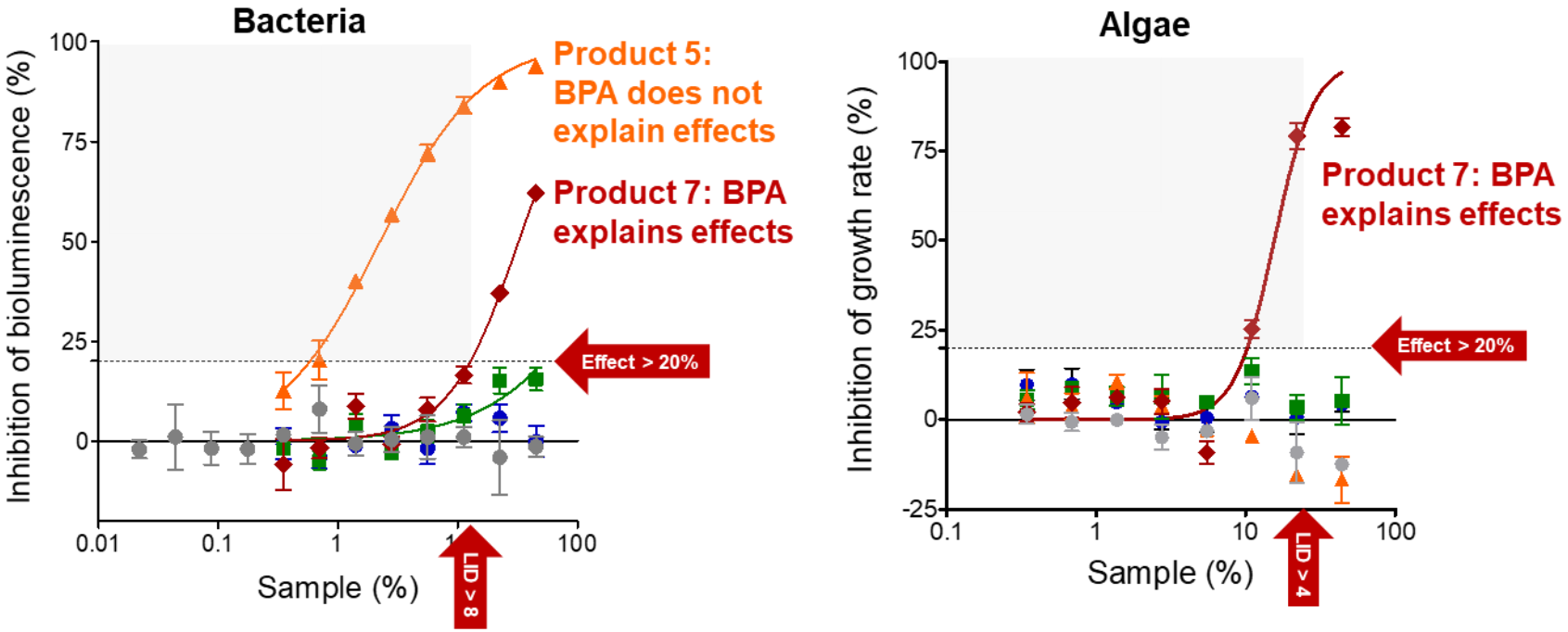
- BPA, BPF, transformation products BADGE were detected
  - A single product without substances of interest
- Hard to derive the environmental performance for this mixture

Product	EC [µS/cm]	TOC [mg/L]	BPA [µg/L]	BPF [µg/L]	BADGE [µg/L]	BADGE-H_2O [µg/L]	BADGE-2H_2O [µg/L]
1	3.1	1.8	<2	<1	83	153	62
2	2.7	1.5	<1	50	<1	1	1
3	22.1	30	<1	<1	1	2	13
4	3.4	7.5	<1	<1	<1	<1	<1
5	4.2	3.3	<1	<1	13	13	7
6	73.0	11.2	2	<1	5	10	9
7	46.7	37.1	10'400	<100	<100	<100	<100
8	6.6	0.8	<10	<10	38	128	46

Vermeirssen et al. (2017) Corrosion protection products as a source of bisphenol A and toxicity to the aquatic environment. Water Research 123, 586-593

Corrosion Protection Coatings: Bioassays

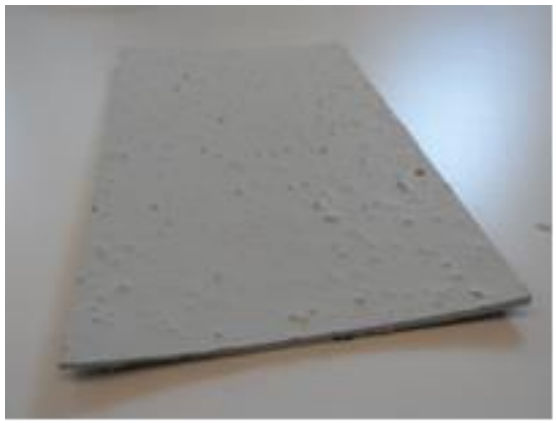
- 6 Products WITHOUT effects to bacteria and algae
  - Product 5: tox not related to measured substances, product 7 : BPA effects
- 4 Products WITHOUT effects to daphnia (not shown)
  - Daphnia toxicity of product 7 based on BPA

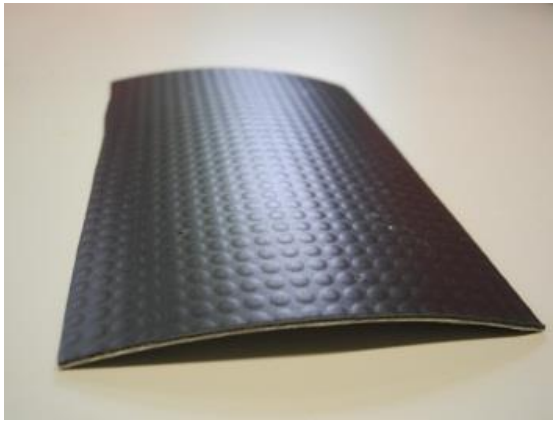


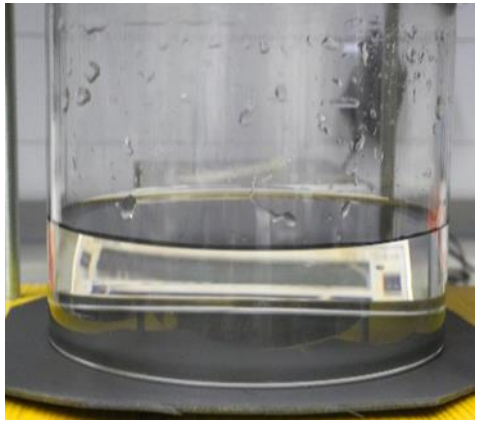
Vermeirssen et al. (2017) Corrosion protection products as a source of bisphenol A and toxicity to the aquatic environment. Water Research 123, 586-593

Roof Membranes

- Professional market products of EPDM, PVC, and FPO membranes
- Surface leached in DSLT
- Chemical analysis of 172 organic additives and 17 phthalates (LC-MS/MS), 16 elements (ICP-MS), TOC
- Three bioassays with eluates 1+2 (24 hours) and eluate 8 (28 days)

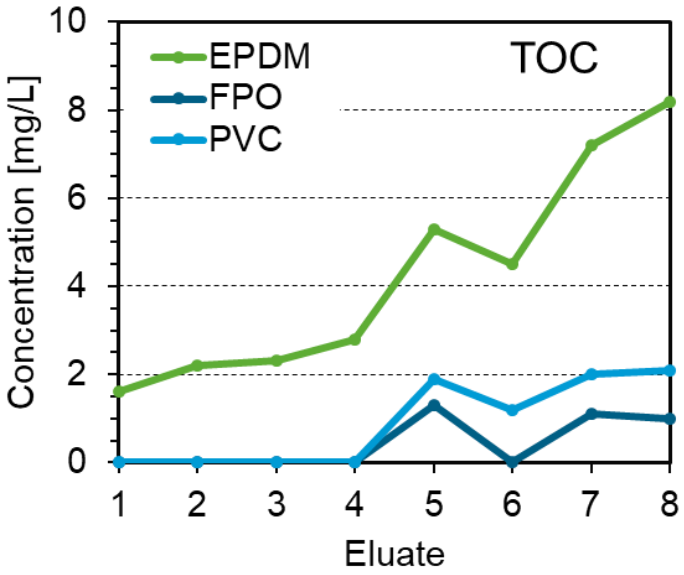


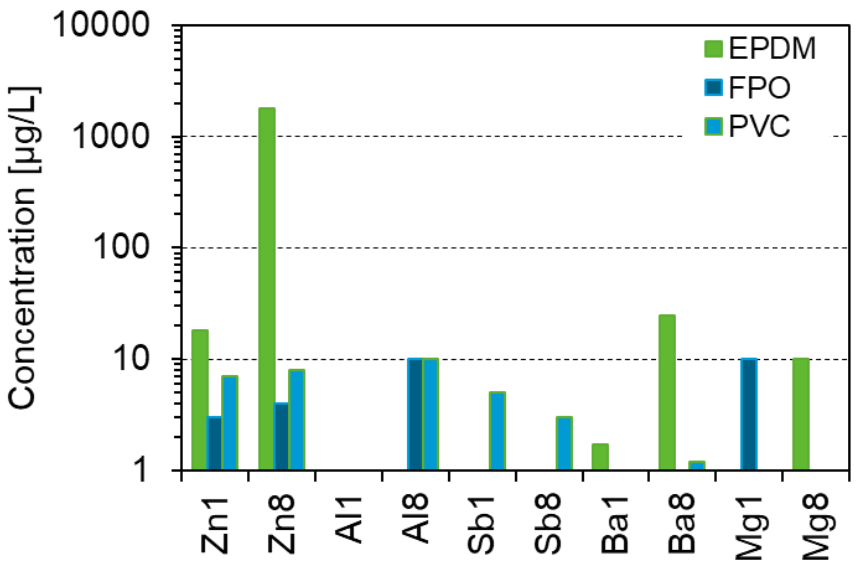




Roof Membranes: Leaching

- Small TOC concentration and slightly increasing for EPDM
- Identified in samples with 24 h (1) and 28 d (8) water contact time
  - EPDM: Zn, Ba, Mg, Hexamethylendiamine, Aniline, 1,3-Benzothiazole
  - PVC: Zn, Al, Sb, Diisononylphthalate
  - FPO: Zn, Al, Mg, 1,1,1-Trimethylolpropane





Burkhardt et al. (under preparation) Auslaugung von Bauprodukten – Ökotoxizitätstest für den Blauen Engel.

Roof Membranes: Bioassays

- PVC shows no release of toxic substances, neither in bioassays nor in chemical analysis
- FPO released Trimethylolpropane and only algae show effects with LID_A 24 and 192
- EPDM effects might be triggered by Benzothiaziole and Zinc

Product	Sample	Algae LID_A	Daphnia LID_D 24 h	Daphnia LID_D 48 h	Bacteria LID_L
EPDM	1+2 (24 h)	12	12	16	128
EPDM	8 (28 d)	96	8	12	96
FPO	1+2 (24 h)	24	≤2	≤2	≤2
FPO	8 (28 d)	192	≤2	≤2	≤2
PVC	1+2 (24 h)	≤2	≤2	≤2	≤2
PVC	8 (28 d)	≤2	≤2	≤2	≤2

Burkhardt et al. (under preparation) Auslaugung von Bauprodukten – Ökotoxizitätstest für den Blauen Engel.

Conclusions

- Toxicity-based approach delivers additional information to leachates
  - Insight to mixtures of leached substances using a test-battery
  - Fulfil lack of information for environmental performance
  - Variability of products easily evaluated
- Laboratory eluates can be used directly
  - CEN/TS 16637-2: Toxicity might increase with contact time
  - EN 16105: Toxicity decreases over nine immersion cycles
- Relevance of test results
  - Substance evaluation in unknown mixtures (good cost/benefit)
  - DF of eluates for declaration of performance (numbers, classes)
  - Guidance to product development (e.g. encapsulation)

Thank you for your attention !